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Organic chemistry in meteorites, comets and the interstellar medium

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Abstract. With the notable exception of those originating on the Moon and Mars, all known meteorites are pieces of objects in the asteroid belt. As such, they have recorded a succession of chemical processes, starting from reactions in the interstellar medium (ISM), followed by reactions that accompanied the formation and evolution of the early solar system, and culminated with reactions during aqueous alteration in the meteorite parent bodies. One of the challenges in meteorite research is to decipher this record and to learn about interstellar formation processes as well as to conditions in the early solar system. The rare class of carbonaceous chondrites contains up to 5 wt% of organic carbon, most of which is locked in an insoluble macromolecular material and only about 20 % of it is in the form of distinct organic compound classes. The molecular and isotopic data of these organic compounds clearly show an interstellar heritage, but a fraction of these precursors were later modified. For example, the amino acids were probably formed inside the meteorite parent body during the aqueous alteration period from simple molecules such as HCN, NH_3 and carbonyl compounds. However, the CI type carbonaceous chondrites contain a significantly distinct amino acid composition, indicating that there may be other synthetic processes involved (Ehrenfreund et al. (2001)).
Polycyclic aromatic hydrocarbons (PAHs) are the probably the most abundant form of organic carbon in the gas phase in the ISM (Allamandola et al. (1989)). PAHs are among the most abundant organic compounds in carbonaceous meteorites, and they have been shown to have a presolar origin (e.g. Messenger et al. (1998)). A fraction of these PAHs are present in an extractable form, while the rest is part of the insoluble macromolecular matter. Progress is being made in the understanding of the evolution of this material in relation to aqueous alteration (Sephton et al. (2000) and oxidation (Cody & Alexander (2005)). Although the potential of cometary meteorites can not be ruled out (Campins & Swindle (1998)), no such macro-meteorite has been recognized in the meteorite collections. Therefore, the organic composition of comets has been inferred mostly from astronomical observations (e.g. Mumma et al. (2003), Crovisier et al. (2004)). Future in-situ investigation of comets with spacecraft such as Rosetta will deliver new data on their organic composition, in particular the non-volatile fraction. However, in order to understand the contributions of different formation processes in primitive solar system objects, the analysis of the organic composition of meteorites remains essential.

Keywords. astrochemistry; comets: general; ISM: moleculess; minor planets, asteroids.

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